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RESEARCH AND DEVELOPMENT IN JAPAN, 1991 UPDATE

Summary

Research and development in Japan continues to be a high, if not major, priority of private and government planners, as shown by the solid growth of aggregate R&D spending. Commercial application of new technology also remains a major goal of both types of planners. Japan's drive to become a net contributor to the global storehouse of scientific resources is gaining momentum, but the consequent shift in R&D spending patterns is lagging. Foreign participation in Japanese research and development is expanding as individual foreign firms take the initiative to engage in programs sponsored by Tokyo as well as private Japanese companies.

Overview

Having rebuilt national research and development capabilities to a par with those of the United States and European countries, Japan's private and government R&D planners have accepted the challenge of making their contribution to global science and technology reflect Japan's economic strength. After decades in which the goal was to catch up technologically with Western industrialized nations, Tokyo has announced that sharing as well as developing technology will be a key part of its new international responsibilities. Accordingly, the government has taken steps to go beyond opening its R&D programs to foreign participation to include input at the planning stage of government projects -- for example, allowing foreign membership on advisory councils. Tokyo also has launched new projects that envision foreign participation as an integral component. If Japan's global R&D contributions are to continue to be expanded, policymakers there will face demands to boost overall spending and to address new priorities and roles.

Aggregate statistics - According to the latest government survey released early this year, total R&D spending in Japan rose 11.2 percent to Y11.8 trillion ($87.5 billion at Y135=$1.00) in the year ending March 31, 1990 (see Table 1a). The FY 1989 figure represents a return to double-digit growth last seen in FY 1985. The sharp drop in the growth rate registered in FY 1986 and its subsequent rebound clearly indicate that Japanese R&D spending is influenced by the pace of overall economic activity.

Data arranged by spending organization shows the corporate sector extending its lead with a 14.1 percent gain to just over Y8.2 trillion ($61 billion). The FY 1989 performances by universities -- up 5.7 percent to just over Y2.1 trillion ($15.8 billion) -- and research institutions, which registered a 4.2 percent increase to more than Y1.4 trillion ($10.8 billion), were significant improvements over the previous year. The pickup in spending by research institutions is particularly striking -- FY 1989's growth rate being six times that recorded in FY 1988. While the government survey does not list a cause for this rebound, one possible explanation is that the impact of economic cycles on spending by research institutions is delayed because their funding is based on multiyear contracts. FY 1988's meager performance may have resulted from the 1985-1986 economic downturn. Another explanation is that outlays by research institutes inherently are volatile since their income depends on the contracts they can attract; with private companies conducting the bulk of their research in-house and government spending subject to political vagaries, funds available to research institutes may vary widely from year to year.

Projections of double-digit profit growth for FY 1989 prompted companies to expand their share of total R&D spending that year to a new record of just under 70 percent. Despite growth rates above the previous year, both universities and research institutions saw their slice of the spending pie shrink in FY 1989. While the share of research institutions has remained within a range of 12 to 14 percent over the past seven years, universities' share has dwindled steadily, falling 5 percentage points between FY 1983 and FY 1989.

The private sector leads the way when the data are presented according to funding source (Table 1b). The business community's 13 percent expansion in FY 1989 confirmed that the negative effects of the 1985-1986 downturn have dissipated entirely. Moreover, the private funding surge reduced the share of the other sources. Public R&D funds grew 4 percent in FY 1989, a sharp improvement over the previous period's tiny 0.3 percent gain. The uptick, however, was only average compared to the past several years. It was not enough to elevate the government's share of total R&D funding back above the long-term 20 percent line held prior to FY 1988; in fact, the 18.6 percent level represents a new low. Previous years have shown that the R&D budget is not safe from the Ministry of Finance's fiscal austerity axe. Whether Tokyo's new commitment to become a global technology source shields government R&D spending against MOF's budget cutters in fiscal year 1992 will be an important indicator of Japan's attitude toward its international role.

For the second year in a row data on Japanese R&D by purpose cast doubt on Japan's willingness to become a source of basic research knowledge. Money

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Table 1: Japan's R&D Expenditures, FY 1983-FY 1989

(in billions of yen and percent)

a. By Spending Organization

Fiscal Year	Companies	Research Institutions	Universities	Total
1983	Y4,560.1	Y971.0	Y1,649.6	Y7,180.8
Change	12.9%	2.3%	7.1%	10.0%
Share	63.5%	13.5%	23.0%	100.0%
1984	5,136.6	1,033.1	1,724.2	7,893.9
Change	12.6%	6.4%	4.5%	9.9%
Share	65.1%	13.1%	21.8%	100.0%
1985	5,939.9	1,160.6	1,789.8	8,890.3
Change	15.6%	12.3%	3.8%	12.6%
Share	66.8%	13.1%	20.1%	100.0%
1986	6,120.2	1,240.2	1,832.6	9,192.9
Change	3.0%	6.9%	2.4%	3.4%
Share	66.6%	13.5%	19.9%	100.0%
1987	6,494.3	1,384.5	1,957.9	9,836.6
Change	6.1%	11.6%	6.8%	7.0%
Share	66.0%	14.1%	19.9%	100.0%
1988	7,219.3	1,394.2	2,014.1	10,627.6
Change	11.2%	0.7%	2.9%	8.0%
Share	67.9%	13.1%	19.0%	100.0%
1989	8,233.8	1,452.3	2,129.4	11,815.5
Change	14.1%	4.2%	5.7%	11.2%
Share	69.7%	12.3%	18.0%	100.0%

b. By Source of Funds

Fiscal Year	Government	Private	Foreign	Total
1983	Y1,721.4	Y5,451.1	Y8.2	Y7,180.8
Change	3.3%	12.3%	17.1%	10.0%
Share	24.0%	75.9%	0.1%	100.0%
1984	1,777.8	6,108.6	7.6	7,893.9
Change	3.3%	12.1%	-7.3%	9.9%
Share	22.5%	77.4%	0.1%	100.0%
1985	1,867.3	7,014.9	8.1	8,890.3
Change	5.0%	14.8%	6.6%	12.6%
Share	21.1%	78.6%	0.1%	100.0%
1986	1,955.3	7,229.7	7.9	9,192.9
Change	4.7%	3.1%	-2.5%	3.4%
Share	21.5%	78.4%	0.1%	100.0%
1987	2,111.8	7,716.6	8.2	9,836.6
Change	8.0%	6.7%	3.8%	7.0%
Share	21.5%	78.4%	0.1%	100.0%
1988	2,117.8	8,501.5	8.3	10,627.6
Change	0.3%	10.2%	1.2%	8.0%
Share	19.9%	80.0%	0.1%	100.0%
1989	2,202.4	9,603.3	9.7	11,815.5
Change	4.0%	13.0%	16.7%	11.2
Share	18.6%	81.3%	0.1%	100.0%

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

for developmental work, which leads directly to commercial products, played a larger role in total R&D budgets in FY 1989, while the proportion allotted to basic research edged back for the second year in a row (see Table 2). If anything, the data indicate that Japan is pulling back from basic research in favor of commercialization. Developmental research won an increased piece of the total spending pie in all but one of the past seven years. The most likely reason behind this trend is the dominant role of private R&D spending in Japan. Despite the fabled long-term outlook and patience of Japanese management, R&D spending, as a whole, still must earn a satisfactory rate of return or make a positive contribution to a company's competitive strength. Private R&D spending naturally tends toward commercial applications, pushing overall spending in the same direction, since the private sector accounts for the majority of Japanese R&D spending and shows the highest growth rate.

Table 2: Japan's Research Expenditures by Purpose, FY 1983-FY 1989

(in billions of yen and percentage share)

Fiscal Year	Basic Research	Applied Research	Developmental Research
1983	Y896.7	Y1,630.1	Y3,882.8
	14.0%	25.4%	60.6%
1984	959.9	1,780.8	4,340.2
	13.6%	25.1%	61.3%
1985	1,030.6	2,001.8	4,985.9
	12.9%	25.0%	62.2%
1986	1,102.8	2,030.8	5,185.0
	13.3%	24.4%	62.3%
1987	1,250.2	2,166.8	5,497.3
	14.0%	24.3%	61.7%
1988	1,288.0	2,346.6	6,041.0
	13.3%	24.3%	62.4%
1989	1,390.9	2,588.4	6,848.0
	12.8%	23.9%	63.2%

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

Data broken down by purpose by spending organization underscore both of the above trends (see Table 3). The breakdown of corporate work among basic, precommercial (applied) and commercial research shows a tiny shift in FY 1989 away from the first two categories in favor of the latter. This shift obscures the fact that since the shares changed very little, the growth of basic research by companies still must be only slightly lower than the growth rate of overall company spending, 14.1 percent. Although basic research outlays by both universities and research institutions declined in FY 1988, they were up as a percentage of total spending in the latest figures. Analysts viewed the modest boost in basic research undertaken by universities as a positive sign (since this category constitutes the bulk of basic research in Japan), yet FY 1989's 53.2 percent mark still is short of levels common between FY 1983 and FY 1987. The gain in basic R&D budgets at research institutions is more positive since

Table 3: Japan's Research Expenditures by Spending Organization by Purpose, FY 1983-FY 1989

(share of each organization's total expenditures in percent)

Fiscal Year	Basic Research	Applied Research	Developmental Research
1983			
Universities	57.4%	35.0%	7.6%
Research Institutions	13.2	33.2	53.6
Companies	5.2	21.8	73.0
1984			
Universities	54.9	36.9	8.3
Research Institutions	12.6	30.9	56.5
Companies	5.7	22.0	72.3
1985			
Universities	54.2	37.4	8.4
Research Institutions	12.3	30.0	57.7
Companies	5.9	21.9	72.1
1986			
Universities	54.2	37.4	8.4
Research Institutions	13.8	27.4	58.8
Companies	6.1	21.6	72.3
1987			
Universities	54.2	37.4	8.4
Research Institutions	15.8	26.0	58.2
Companies	6.6	21.7	71.7
1988			
Universities	52.8	38.5	8.7
Research Institutions	14.9	25.4	59.7
Companies	6.6	21.7	71.7
1989			
Universities	53.2	38.1	8.7
Research Institutions	15.3	25.7	59.0
Companies	6.4	21.5	72.2

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

FY 1989's 15.3 percent share is near the historical high of 15.8 percent reached in FY 1987.

Government Spending - Faced with ballooning interest payments on the national debt, Japanese budget planners have been preoccupied with fiscal austerity since the early 1980s (see JEI Report No. 17A, May 3, 1991). To balance the budget the Ministry of Finance has asked other government agencies to freeze capital expenditures (such as public works and other infrastructure) and reduce current operating outlays (including administrative costs and wages) by 5 percent each year. The government was able to keep a lid on new spending through the mid-1980s, but its grip began to slip at the end of the decade and has become almost loose as Japan strives to meet greater domestic and international expectations. The importance Tokyo attaches to R&D clearly is more than rhetorical but is not unbounded. Table 4 shows that the growth of research outlays

Table 4: Japanese Government Research Expenditures as a Share of the General Account Budget, FY 1982-FY 1991

(revised budgets in billions of yen and percent)

a. As a Share of Total Expenditures

Fiscal Year	Total Expenditures	Research Expenditures	Share
1982	Y47,562.1	Y1,448.0	3.0%
1983	50,839.4	1,448.9	2.8
1984	51,513.4	1,477.6	2.9
1985	53,222.9	1,521.6	2.9
1986	53,824.8	1,599.0	3.0
1987	58,241.2	1,655.0	2.8
1988	61,851.7	1,715.7	2.8
1989	66,311.9	1,814.8	2.7
1990	69,651.2	1,920.9	2.8
1991*	70,347.4	2,022.6	2.9

b. As a Share of Discretionary Expenditures

Fiscal Year	Total Expenditures	Research Expenditures	Share
1982	Y33,120.0	Y1,448.0	4.4%
1983	35,356.8	1,448.9	4.1
1984	33,244.5	1,477.6	4.4
1985	33,352.3	1,521.6	4.6
1986	33,425.7	1,599.0	4.8
1987	35,276.5	1,655.0	4.7
1988	36,789.8	1,715.7	4.6
1989	39,257.4	1,814.8	4.6
1990	39,271.0	1,920.9	5.0
1991*	37,238.2	2,022.6	5.4

*Initial budget.

Source: Ministry of Finance

has kept pace with the expansion of total spending (its share has varied only marginally) but has outrun discretionary spending (as shown by its gradually increasing share). As important as R&D spending is, it is not a top priority, however. Outlays for foreign aid, defense and public works all have enjoyed higher growth rates than R&D in the past and are likely to continue to do so in the future.

When government R&D spending is broken down by agency for the most recent two fiscal years (see Tables 5 and 6), FY 1991 appears to come up short of the previous year's mark. Overall R&D spending growth for FY 1991 initially was budgeted at 5.3 percent, less than FY 1990's final mark of 5.7 percent. Unlike previous years, when the pattern of outlays was chaotic, the direction of

Table 5: Japanese Government R&D Expenditures, Revised FY 1990

(in millions of yen and percentage change)

	Science Promotion	Energy and Other Research	Special Research*	Total
Diet	Y523	Y0	Y0	Y523
	0.0%	--	--	0.0%
Japan Technology Council	0	951	0	951
	--	9.7%	--	9.7%
Police Agency	1,096	0	0	1,096
	3.4%	--	--	3.4%
Hokkaido Development Agency	144	0	0	144
	1.4%	--	--	1.4%
Defense Agency	0	104,268	0	104,268
	--	12.0%	--	12.0%
Economic Planning Agency	825	0	0	825
	5.8%	--	--	5.8%
Science and Technology Agency	203,648	164,933	124,937	493,518
	8.2%	-0.7%	12.4%	6.0%
Environment Agency	9,141	0	0	9,141
	16.9%	--	--	16.9%
Justice Ministry	950	0	0	950
	7.8%	--	--	7.8%
Foreign Ministry	0	7,095	0	7,095
	--	10.7%	--	10.7%
Finance Ministry	373	0	730	1,102
	2.7%	--	-1.1%	0.1%
Education Ministry	72,770	129,907	689,721	892,398
	9.1%	1.2%	4.9%	4.7%
Health Ministry	38,830	1,319	10,092	51,241
	6.8%	13.5%	2.3%	5.9%
Agriculture Ministry	65,298	2,544	3,300	71,141
	2.9%	11.2%	-2.9%	2.9%
International Trade and Industry Ministry	55,940	12,912	181,340	250,192
	-0.4%	-5.3%	10.4%	6.9%
Transportation Ministry	13,184	3,311	1,039	17,534
	-1.2%	53.2%	13.3%	6.8%
Posts and Telecommunications Ministry	4,561	189	26,543	31,292
	2.9%	79.8%	0.5%	1.1%
Labor Ministry	633	38	3,522	4,193
	3.0%	5,483.6%	-11.0%	-8.1%
Construction Ministry	5,668	454	0	6,122
	2.8%	45.3%	--	5.1%
Home Affairs Ministry	582	0	0	582
	1.8%	--	--	1.8%
Total	474,166	427,921	1,016,222	1,918,309
	6.1%	3.3%	6.6%	5.7%

*Column adds to more than the total because of double-counting of budgets for projects shared by more than one agency.

Source: Japan Society for the Promotion of Science, Japanese Scientific Monthly, July 1991.

Table 6: Japanese Government R&D Expenditures, Initial FY 1991

(in millions of yen and percentage change)

	Science Promotion	Energy and Other Research	Special Research*	Total
Diet	Y533	Y0	Y0	Y533
	0.0%	--	--	0.0%
Japan Technology Council	0	1,051	0	1,051
	--	10.5%	--	10.5%
Police Agency	1,143	0	0	1,143
	8.3%	--	--	8.4%
Hokkaido Development Agency	148	0	0	148
	-0.5%	--	--	-0.5%
Defense Agency	0	115,045	0	115,045
	--	10.3%	--	10.3%
Economic Planning Agency	850	0	0	850
	5.1%	--	--	5.1%
Science and Technology Agency	223,942	165,575	133,045	522,561
	9.3%	0.4%	6.5%	5.6%
Environment Agency	10,900	0	0	10,900
	18.3%	--	--	18.3%
Justice Ministry	1,006	0	0	1,006
	7.1%	--	--	7.1%
Foreign Ministry	0	8,160	0	8,160
	--	15.0%	--	15.0%
Finance Ministry	381	0	811	1,193
	6.4%	--	11.2%	9.7%
Education Ministry	76,576	131,030	728,718	936,324
	2.5%	0.9%	5.7%	4.7%
Health Ministry	42,278	2,159	11,707	56,144
	8.9%	63.7%	5.5%	9.6%
Agriculture Ministry	67,450	2,807	3,300	73,577
	5.1%	6.2%	0.0%	4.9%
International Trade and Industry Ministry	56,465	13,843	185,605	255,913
	1.6%	4.4%	1.6%	1.7%
Transportation Ministry	13,443	5,926	1,145	20,514
	2.9%	79.0%	11.0%	17.9%
Posts and Telecommunications Ministry	5,072	232	28,600	33,904
	13.5%	22.6%	10.0%	10.6%
Labor Ministry	673	6	4,367	5,046
	6.8%	-83.6%	24.0%	20.4%
Construction Ministry	5,892	732	0	6,624
	6.6%	61.2%	--	10.8%
Home Affairs Ministry	616	0	0	616
	9.1%	--	--	9.1%
Total	507,368	446,565	1,068,698	2,022,631
	6.7%	4.2%	5.1%	5.3%

*Column adds to more than the total because of double-counting of budgets for projects shared by more than one agency.

Source: Japan Society for the Promotion of Science, Japanese Scientific Monthly, July 1991.

spending in FY 1991 is more evenly upward. Only two items have faced reductions in the current fiscal year, compared with five in FY 1990. Agencies that logically have a strong claim to government R&D funds, such as the Science and Technology Agency and the Ministry of International Trade and Industry, show smaller gains in FY 1991 compared to the previous year. The Education Ministry's unchanged growth rate disappointed many observers because the ministry has pledged both to upgrade research at the nation's universities and to bolster basic research, a task that will require significant infusions of money. For a handful of other agencies, FY 1991 portends a prosperous year, typified by the Labor Ministry (up 20.4 percent after dropping the previous year), the Environment Agency (18.3 percent) and the Transportation Ministry (17.9 percent). The FY 1991 increase inked in for the Environment Agency is noteworthy as it represents the second straight significant gain. The Japan Defense Agency's R&D budget also continues to lead a charmed life, with FY 1991's growth rate still in double digits. JDA is planning to double R&D's share of its budget from 2.5 percent to 5 percent by FY 1995. Ideally this would mean that defense-related research would rise even if overall defense spending growth slows or halts. The end of the Cold War and new prospects for warmer relations between Japan and the new Soviet Union, however, may put a damper on defense-related R&D in future years.

A better idea of each agency's priorities can be derived from a detailed look at FY 1990-FY 1991 spending plans (see Table 7). In general, government planners continue to hew to well-established courses. Nuclear power remains high on the list of priorities, with STA, MITI and the Foreign Ministry devoting a steady stream of resources toward this area. The promotion of new technologies -- such as STA's fund for innovative and basic research, MITI's large-scale industrial technology program and the Ministry of Transportation's magnetic levitation research -- also accounts for a significant share of spending.

Basic research, which includes MITI's Human Frontiers Science Program and the Basic Technology Promotion Center (a joint venture of MITI and the Ministry of Posts and Telecommunications), also gained ground in FY 1991. Although the Education Ministry's overall FY 1991 budget showed growth equal that of FY 1990, more money is to be channeled into university research programs this year, as shown by the 5.7 percent boost in spending for this purpose. Grant money for university researchers, however, shows only a scant gain of 0.9 percent. A dominant theme in Japan's basic research program appears to be internationalism -- either inviting foreign researchers to come to Japan or forming joint projects to carry out research around the globe.

Environmental research clearly is gathering momentum; most agencies boosted funding for their initiatives in this area in FY 1991. STA, in particular, is carving out a leading role in this field; its Green Planet Project and environmental research budget together are nearly six times larger than the Environment Agency's corresponding outlays (those not associated with disaster prevention). Even MITI's two-year-old Global Environment Industrial Technology Institute has a budget almost as big as the nondisaster-oriented research in the Environment Agency (Y6,748 million or $50 million versus Y7,677 million or $56.9 million). This budget juggling has led some skeptics to question whether bureaucrats truly are interested in green policies or are hitching a ride on the environmental bandwagon to boost their budgets.

Overall, public spending has followed the tried-and-true approach that helped foster the nation's economic vigor, with funds focused on developing

Table 7: Expenditures on Selected Science Programs by Agency, FY 1990-FY 1991

(in millions of yen)

	FY 1990	FY 1991
Japan Defense Agency		
Technology development	Y104,268	Y115,045
Science and Technology Agency		
Promotion of innovative and basic technology	7,637	10,127
Green Planet Project (global warming)	4,708	10,306
Human Frontiers Science Program	1,872	2,194
Science and technology promotion	11,843	14,397
Science policy administration	10,837	11,189
Nuclear energy research	296,215	306,435
Outerspace research	119,416	131,769
Ocean technology development	9,864	10,666
Environmental, planetary research	26,133	35,662
Materials research	11,958	13,548
Superconducting materials	3,460	3,087
Intelligent materials	0	271
Life sciences research	16,441	18,976
Optical technology research	10,688	9,329
Environment Agency		
National Environment Research Institute	4,899	5,977
Global environmental research	1,200	1,700
National Disaster Prevention Institute	1,928	1,928
Disaster prevention survey	1,015	1,186
Foreign Ministry		
International Atomic Energy Commission	2,956	3,604
OECD Nuclear Power Committee	200	324
Finance Ministry		
Brewing Research Institute	358	381
Printing Agency Research Institute	730	811
Education Ministry		
Research grants	55,800	58,900
Japan Technology Promotion Council grants	6,148	6,661
University research programs	689,721	728,718
National university research grants	129,907	131,029
Health Ministry		
Agency research	15,706	16,926
Research grants	18,844	20,391
Pharmaceutical research	2,300	2,300
Health science research	6,467	7,426
Cancer research projects	3,254	3,352
International cancer research	170	176
Medical and drug information system	242	149
Agriculture Ministry		
Agency research laboratories (including 29 agricultural research centers)	59,221	62,421
Large-scale projects	1,302	1,316
Biotechnology development	1,565	1,820
Livestock research	4,171	4,222
Tropical agriculture research	672	716

Table 7 (continued)

(in millions of yen)

	FY 1989	FY 1990
Red tide research	278	265
Food product technology	589	642
International Trade and Industry Ministry		
Agency research (including 16 research centers)	39,027	41,026
Large-scale industrial technology projects	13,120	13,460
Basic computer technology development	3,465	3,083
Basic Technology Promotion Center	26,000	28,600
Next-generation basic technology projects	7,463	7,869
New energy technology development projects	27,475	24,817
Energy conservation projects	11,119	11,487
Nuclear energy development projects	29,772	28,724
Human Frontiers Science Program	1,337	1,515
International aircraft development	3,817	3,670
Global Environment Industrial Technology Institute	6,070	6,748
Small business technology improvement	1,612	1,612
Transportation Ministry		
Agency research (including five ship technology centers)	8,452	9,088
Geostationary weather satellite management	2,130	2,154
Geostationary weather satellite launches	3,272	2,946
Magnetic levitation train technology	2,227	4,705
Next-generation ship technology	800	936
Posts and Telecommunications Ministry		
Electrotechnical laboratories	4,468	5,072
Communications Frontier Research	389	470
Basic Technology Promotion Center	26,000	28,600
Labor Ministry		
Agency research	2,432	3,152
Industrial safety research	1,354	2,043
Japan Bioassay Research Center	1,313	1,363
Construction Ministry		
Agency research (including one engineering center)	4,778	5,055
Construction technology research	734	765

Source: Japan Society for the Promotion of Science, Japanese Scientific Monthly, July 1991.

precommercial know-how. This has been particularly true in areas that are considered too risky for private companies to bear the full costs on their own, such as space development. New facets of government R&D are providing increased support for basic and international research ("international" in that it either involves foreign participation or is aimed at global issues). In light of the fact that most of these new categories fared well in the FY 1991 budget, Tokyo appears to be preparing new channels that will direct the flow of government R&D spending well into the next century. The success or failure of these new directions, however, is not dependent on funding alone. Support from the private sector and foreigners will be equally important factors.

Private Spending - The data in Tables 1 and 2 underscore the increasingly dominant role of private R&D in Japan. Companies outspent the government four-to-one in FY 1989, a ratio that probably tipped even more toward the private sector's favor the following fiscal year, based on reports of double-digit growth in capital investment. Intense competition -- both domestic and foreign -- has stimulated Japanese companies to adopt a strong technology development program as a key element of their business strategies. Technology drives down production costs, can pare the size as well as energy consumption of products, differentiates products from those of competitors' via innovative features, and leads to new products and markets. While not completely immune to corporate planners' profit motives, R&D budgets have been spared the full blow of the cost cutter's axe during slow business periods because R&D is considered crucial to a firm's future competitiveness. Record corporate profits during the late 1980s can be traced, at least partly, to strong R&D spending in previous years. Thanks to these record profits R&D budgets have continued to expand rapidly, positioning Japanese firms for leadership in many areas through the 1990s.

The latest government data on private R&D extend only through FY 1989 but still show a general surge in spending, except in agriculture (see Table 8). Whereas 11 sectors recorded single-digit increases in FY 1988, only six industries registered single-digit gains the following year. Although the two industries that cut R&D spending in FY 1989 did so sharply (agriculture off 46.3 percent and mining by 12.5 percent), these sectors account for less than 0.4 percent of total private outlays. It is not clear from the government survey why these two sectors slashed research spending, but they have a history of volatility. The great majority of the 30-odd industries surveyed by the Management and Coordination Agency turned in double-digit performances, with standouts worth noting at both ends of the spectrum. Among the industries that nearly doubled or tripled the rate of R&D spending growth were: publishing, petroleum, plastics, fabricated metal products and nonelectric machinery. Conversely, eight sectors slowed their rate of spending increase; these included pulp and paper as well as nonferrous metals. Perhaps most significant, the industries where Japan is already a strong international competitor -- textiles, chemicals, nonelectric and electric machinery plus transportation equipment -- all showed solid gains. It is clear that Japanese firms have no intention of resting on their laurels in the technology race.

The commitment of Japanese management to R&D is obvious when it is expressed as a share of gross sales (see Table 9). Over the past 11 years, only one sector -- agriculture -- recorded a lower R&D-to-gross sales ratio at the end of the period than at the beginning. Of particular note are the industries once considered technologically mature that have transformed gradually into dynamic high technology industries. Japan's textile industry, for example, continues to roll out new products with unique qualities, such as temperature-sensitive coloration, shape-memory retention, absorption or reflection of solar energy, and unusual textures and finishes. These products are a direct result of the industry doubling its ratio of R&D to sales over the past decade. This ratio also has risen strongly in industries traditionally considered technology-intensive, such as communications and electronics, pharmaceuticals, and precision machinery.

Since private R&D is where most of the action is taking place in Japan, it is not surprising that international pressure is building for companies to

Table 8: Japan's R&D Expenditures by Industry, FY 1988-FY 1989

(in billions of yen and percentage change)

	FY 1988		FY 1989	
	Total	Change	Total	Change
Agriculture	Y8.2	41.4%	Y4.4	-46.3%
Mining	28.1	44.1	24.6	-12.5
Construction	148.5	15.7	185.1	24.7
Manufacturing	6,754.6	10.7	7,706.2	14.1
Food Products	179.3	0.1	203.6	13.5
Textiles	72.8	9.5	81.3	11.6
Pulp and Paper	42.8	27.8	45.5	6.3
Publishing and Printing	25.4	17.1	33.7	33.0
Chemicals	1,190.2	8.6	1,313.9	10.4
Industrial Chemicals and Synthetic Fibers	501.5	10.8	552.0	10.1
Oils and Paints	116.3	4.4	134.5	15.6
Pharmaceuticals	416.2	9.3	456.0	9.5
Other	156.2	3.3	171.4	9.7
Petroleum and Coal Products	75.0	6.8	84.2	12.3
Plastic Products	90.9	5.8	120.8	32.8
Rubber Products	101.5	19.1	111.8	10.1
Nonmetallic Mineral Products	198.6	11.6	221.4	11.5
Steel	249.7	1.8	268.1	7.4
Nonferrous Metals	120.3	15.2	127.0	5.6
Fabricated Metal Products	89.6	-5.5	109.3	22.0
Nonelectric Machinery	451.0	7.7	559.0	23.9
Electric Machinery	2,451.6	13.3	2,808.1	14.5
Communications and Electronics Equipment	1,709.8	14.2	1,941.7	13.6
Other	741.8	11.4	866.4	16.8
Transportation Equipment	1,086.4	12.0	1,244.6	14.6
Motor Vehicles	932.4	14.4	1,087.2	16.6
Other	154.0	-0.5	157.4	2.2
Precision Machinery	238.8	16.9	266.1	11.5
Other	90.8	6.9	107.8	18.7
Transportation, Communications and Utilities	279.9	16.9	313.5	12.0
Total	7,219.3	11.2	8,233.8	14.1

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

share their technology. Japanese companies are faced with two demands: increase funding for basic research (which is to be freely shared) and transfer more technology to foreign partners. As mentioned above, the business sector moved more of its R&D outlays in FY 1989 to developmental research and away from basic and applied work. Table 10 shows that while the overall figures may have moved in one direction, the allocations by individual industries reveal a more haphazard pattern of spending decisions. With regard to basic research,

Table 9: Japan's Ratio of Corporate R&D Expenditures to Gross Sales by Industry, FY 1978-FY 1989

(in percent)

Industry	FY 1978	FY 1983	FY 1988	FY 1989
Agriculture	0.60%	0.26%	0.38%	0.21%
Mining	0.54	0.59	1.27	0.94
Construction	0.42	0.53	0.49	0.52
Manufacturing	1.82	2.31	3.15	3.29
Food Products	0.51	0.70	0.89	1.07
Textiles	0.77	0.90	1.50	1.71
Pulp and Paper	0.49	0.63	0.87	0.79
Publishing and Printing	0.36	0.43	0.63	0.71
Chemicals	2.71	3.34	4.63	4.84
Industrial Chemicals and Synthetic Fibers	1.92	2.32	3.92	4.09
Oils and Paints	2.73	2.83	3.74	3.93
Pharmaceuticals	5.00	6.59	6.94	7.50
Other	3.03	3.04	4.11	4.11
Petroleum and Coal Products	0.27	0.26	0.83	0.72
Plastic Products	n.a.	n.a.	2.21	2.73
Rubber Products	2.60	2.40	3.19	3.25
Nonmetallic Mineral Products	1.29	1.82	2.73	2.75
Steel	1.08	1.60	2.13	2.21
Nonferrous Metals	1.00	1.49	2.00	1.91
Fabricated Metal Products	1.08	1.31	1.48	1.36
Nonelectric Machinery	1.93	2.57	2.60	2.83
Electric Machinery	3.74	4.70	5.53	5.89
Communications and Electronics Equipment	3.89	4.85	5.66	6.10
Other	3.59	4.40	5.25	5.47
Transportation Equipment	2.44	2.66	3.31	3.40
Motor Vehicles	2.60	2.89	3.31	3.48
Other	1.90	1.86	3.31	2.93
Precision Machinery	3.15	4.02	4.85	5.16
Other	1.16*	1.30*	1.14	1.19
Transportation, Communications and Utilities	0.35	0.39	0.95	1.06
All Industry Average	1.57	1.97	2.60	2.72

*Includes plastic products.

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

exactly as many industries cut the proportion of their spending in this area (13) as increased it between FY 1988 and FY 1989. Despite an overall increase in the private sector's share of developmental research, more sectors reduced the share of funds for this category than increased it in FY 1989 by a solid margin (15 to 11). The distribution of spending emphasis is predictable, with

Table 10: Japan's Corporate R&D Expenditures by Purpose, FY 1988-FY 1989

(in percent of total sectoral spending)

Industry	Basic Research		Applied Research		Developmental Research	
	1988	1989	1988	1989	1988	1989
Agriculture	5.4%	8.8%	33.4%	30.9%	61.2%	60.3%
Mining	23.0	17.0	31.3	28.1	45.7	54.9
Construction	5.7	6.1	29.7	22.8	64.6	71.1
Manufacturing	6.3	6.4	21.2	21.0	72.5	72.6
Food Products	10.1	12.1	31.7	32.3	58.2	55.6
Textiles	6.2	6.1	30.6	26.9	63.2	67.0
Pulp and Paper	5.1	4.2	31.1	26.0	63.8	69.8
Publishing and Printing	2.8	5.9	29.9	45.3	67.3	48.8
Chemicals	11.9	13.7	29.4	27.8	58.7	58.5
Industrial Chemicals and Synthetic Fibers	8.8	10.7	32.3	30.0	58.9	59.4
Oils and Paints	5.2	4.4	34.9	33.3	60.0	62.2
Pharmaceuticals	18.8	20.9	28.3	26.8	53.0	52.3
Other	8.7	11.4	19.1	19.1	72.2	69.5
Petroleum and Coal Products	13.3	11.1	20.9	24.3	65.9	64.6
Plastic Products	6.8	3.0	28.5	25.4	64.7	71.6
Rubber Products	4.8	4.1	17.0	19.8	78.2	76.2
Nonmetallic Mineral Products	7.6	8.3	20.1	22.4	72.3	69.3
Steel	9.8	10.8	24.5	25.0	65.7	64.2
Nonferrous Metals	3.5	4.3	28.9	29.2	67.6	66.5
Fabricated Metal Products	2.2	2.3	13.3	16.1	84.5	81.6
Nonelectric Machinery	4.4	3.9	20.4	21.0	75.2	75.0
Electric Machinery	4.3	4.1	19.1	18.7	76.6	77.2
Communications and Electronics Equipment	4.2	3.9	18.6	18.5	77.1	77.6
Other	4.5	4.7	20.1	19.0	75.4	76.3
Transportation Equipment	4.7	4.1	14.3	13.4	81.0	82.5
Motor Vehicles	4.6	3.9	12.9	11.8	82.5	84.2
Other	5.5	5.3	22.8	24.3	71.7	70.4
Precision Machinery	4.2	4.3	18.6	22.2	77.2	73.5
Other	4.3	4.2	19.9	22.1	75.8	73.7
Transportation, Communications and Utilities	12.5	5.5	28.2	32.1	59.3	62.4
All Industry Average	6.6	6.4	21.7	21.5	71.7	72.2

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

industries such as petroleum and chemicals (pharmaceuticals, in particular) devoting a relatively high proportion of their R&D budgets to basic research, while machinery and equipment makers have concentrated their monies on development.

Technology Trade - Perhaps the area in which the international community has the highest expectations of Japan is in technology trade. Japanese

companies must combat their reputation as global technology scavengers and hoarders before their recent offers of technological assistance will be viewed with less suspicion by foreigners. The biggest obstacle to greater technology transfers is linked closely to the private sector's leading role in Japanese R&D, which means that much of the most desirable technology is in the hands of private companies, not the government. Private firms understandably are loathe to disclose potentially important know-how to competitors and even less inclined to do so without adequate licensing or royalty fees. While foreigners may feel Japan is indebted to the rest of the free-market world for relatively unlimited access to foreign technology that contributed to the island nation's commercial success, Japanese argue that their success is due as much to their own efforts as to the foreign technology, which they readily admit they absorbed. In addition, Japanese argue that their technology-gathering was aboveboard and paid for via licensing fees and royalties. Nevertheless, Tokyo has committed Japan to becoming a net contributor of technology, particularly to developing nations.

The latest government data on technology flows indicate that Japan is making progress toward this goal. Exports of technology in FY 1989 surpassed imports in the number of transactions and nearly exceeded the total value of imports (see Tables 11 and 12). When only new technology transactions (excluding payments or renewals of previous deals) are considered, the picture is unambiguous, with exports easily topping imports in both number and value terms. In fact, in numbers of cases it is clear that Japan has been a net exporter of new technology for some years.

Table 11: Japan's Technology Imports, FY 1975-FY 1989

(number of approved cases and value in billions of yen)

	Cases		Value	
	Total	Of Which New:	Total	Of Which New:
FY 1975	6,766	796	169.1	Y13.3
FY 1976	6,050	632	177.3	17.9
FY 1977	6,659	685	190.1	16.9
FY 1978	6,573	936	192.1	38.2
FY 1979	7,012	1,020	241.0	26.8
FY 1980	7,248	919	239.5	27.7
FY 1981	7,207	844	259.6	24.9
FY 1982	6,936	929	282.6	44.4
FY 1983	7,839	1,073	279.3	42.4
FY 1984	7,316	982	281.4	31.8
FY 1985	7,679	1,245	293.2	33.3
FY 1986	7,494	1,141	260.6	33.6
FY 1987	7,373	813	283.2	56.2
FY 1988	8,356	1,382	312.2	54.6
FY 1989	7,109	1,056	329.9	48.4

The picture becomes sharper when the data are broken down by industry (see Table 13). The manufacturing sector, which naturally accounts for the bulk of activity, partially reversed its position between FY 1988, when it was a net

Table 12: Japan's Technology Exports, FY 1975-FY 1989

(number of approved cases and value in billions of yen)

	Cases		Value	
	Total	Of Which New:	Total	Of Which New:
FY 1975	2,811	1,073	66.6	Y18.9
FY 1976	2,767	775	83.4	27.0
FY 1977	2,880	897	93.3	36.3
FY 1978	3,157	1,063	122.0	47.1
FY 1979	3,667	1,087	133.1	52.1
FY 1980	4,103	1,237	159.6	74.3
FY 1981	4,877	2,017	175.1	70.8
FY 1982	4,738	1,970	184.9	63.3
FY 1983	6,403	2,494	240.9	74.9
FY 1984	5,426	1,824	277.5	90.9
FY 1985	5,885	2,099	234.2	73.3
FY 1986	5,469	1,730	224.1	51.8
FY 1987	5,955	1,655	215.6	44.8
FY 1988	6,352	1,850	246.3	47.4
FY 1989	7,559	2,086	329.3	66.6

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

importer of technology in both numerical and value terms, and FY 1989, when it became a net exporter at least in terms of cases. The FY 1989 turnaround resulted from both a surge in the number and the value of exports and a sharp fall in imports. Manufacturers of fabricated metal products and, in particular, firms in the textile and synthetic fibers industries increased their technology licensing activities in FY 1989. Interestingly, however, the amount of royalties and fees earned by these sectors increased proportionately only for synthetic fibers.

On the import side, the downward trend spread across nearly two out of every three sectors. Some sectors, in fact, recorded surprisingly sharp drops. The electronics sector, for example, accounted for the bulk of the decline between FY 1988 and FY 1989 when the number of its import contracts dropped from 2,416 to 1,376. (Paradoxically, the value of these contracts rose from Y79.3 billion or $587.4 million to Y92 billion or $681.5 million.)

When technology trade is analyzed by country (see Table 14), the pattern is mixed. Exports of Japanese technology to Asian nations, the United States and Western Europe generally exhibited good gains between FY 1986 and FY 1989. Obtaining Japanese technology is a top goal of the rapidly industrializing economies of Asia. South Korea has been particularly vocal on this issue; this may have been one factor behind the big jump in Japanese technology exports to that nation in FY 1989. Other Asian countries, including China and India, also are tapping in to Japanese technology with increasing frequency. Transfers of Japanese know-how to its Western industrialized allies also rose solidly in FY 1989, particularly to the United States.

Imports of technology slowed in FY 1989, particularly from the United States, although interest in German and British know-how revived somewhat that year. Contracts to obtain U.S. technology dropped by almost 27 percent in

Table 13: Japan's Corporate Technology Trade by Industry, FY 1988-FY 1989

(number of cases and value in billions of yen)

	FY 1988				FY 1989			
	Exports		Imports		Exports		Imports	
	Cases	Value	Cases	Value	Cases	Value	Cases	Value
Total	6,352	Y246.3	8,356	Y312.2	7,559	Y329.3	7,109	Y329.9
Agriculture	8	0.1	5	0.0	5	0.0	1	0.0
Mining	11	0.1	35	0.1	9	0.0	27	0.3
Construction	387	16.8	171	1.0	219	12.4	290	2.0
Manufacturing	5,887	228.6	8,119	309.5	7,286	316.2	6,776	326.9
Food Products	118	5.8	123	13.4	142	8.3	93	8.5
Textiles	191	4.4	143	4.9	358	4.6	95	4.8
Pulp and Paper	29	0.5	27	0.8	36	0.6	21	1.3
Publishing	29	0.4	70	0.9	33	0.4	91	1.6
Chemicals	1,185	48.1	1,044	50.3	1,297	53.6	942	56.9
Synthetic Fibers	561	27.1	446	20.5	610	29.5	473	23.2
Fertilizers	241	3.1	259	4.3	253	3.8	136	5.0
Pharmaceuticals	294	16.3	231	18.2	317	18.9	252	21.5
Other	89	1.6	108	7.3	117	1.5	81	7.2
Petroleum and Coal Products	12	0.2	103	2.2	14	0.5	113	3.8
Plastic Products	95	1.3	84	1.2	94	1.2	89	1.3
Rubber Products	93	2.9	105	3.7	174	4.8	108	3.8
Nonmetallic Mineral Products	277	5.7	154	3.7	252	9.0	174	4.1
Steel	422	10.8	359	7.9	551	21.6	320	4.8
Nonferrous Metals	207	2.0	195	14.6	267	7.1	221	10.7
Fabricated Metal Products	155	1.1	172	2.2	409	2.0	154	2.3
Nonelectric Machinery	700	10.8	1,112	22.6	777	13.2	1,270	33.0
Electric Machinery	1,476	68.8	2,889	113.8	1,669	86.7	1,825	120.6
Machine Tools	670	21.0	473	34.5	689	28.2	449	28.5
Electronics	806	47.7	2,416	79.3	980	58.5	1,376	92.0
Transportation Equipment	684	58.4	789	52.0	777	87.1	819	54.9
Motor Vehicles	447	54.2	260	6.6	525	83.0	250	7.2
Other	237	4.2	529	45.4	252	4.1	569	47.7
Precision Machinery	114	4.6	255	7.3	320	12.6	290	8.3
Other	100	2.8	495	8.1	116	2.9	151	6.3
Transportation, Communications and Utilities	59	0.7	26	1.6	40	0.6	15	0.7

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

Table 14: Japan's Corporate Technology Trade by Country, FY 1986-FY 1989

(number of cases and value in billions of yen)

a. Exports

	FY 1986		FY 1987		FY 1988		FY 1989	
	Cases	Value	Cases	Value	Cases	Value	Cases	Value
Asia	2,748	Y86.5	3,152	Y86.4	3,264	Y101.4	3,965	Y128.9
China	454	19.7	405	9.4	339	8.4	473	8.1
Taiwan	532	8.5	590	12.3	660	13.2	609	16.3
South Korea	732	21.1	816	27.5	888	30.6	1,350	38.5
Thailand	203	5.4	294	7.3	331	9.9	364	17.6
Philippines	89	0.6	133	2.0	n.a.	n.a.	n.a.	n.a.
Indonesia	196	4.4	182	3.2	228	13.6	304	10.9
Malaysia	128	3.2	147	3.1	128	4.0	221	6.3
India	196	4.4	182	3.2	211	5.4	245	6.2
West Asia	94	10.5	52	1.6	59	2.3	72	2.4
North America	1,006	62.3	1,058	72.5	1,225	77.0	1,671	115.1
United States	869	57.7	912	65.9	1,080	71.1	1,445	107.7
South America	216	5.2	198	4.5	195	4.4	182	4.6
Brazil	127	3.8	107	2.5	114	2.5	n.a.	n.a.
Europe	1,040	43.6	1,184	40.3	1,281	49.3	1,342	65.1
Great Britain	161	7.6	190	10.6	221	13.9	251	20.0
West Germany	247	7.8	297	7.4	301	10.7	328	13.7
France	145	5.9	162	5.2	137	4.4	149	7.1
Netherlands	41	2.5	53	2.1	86	2.2	71	2.1
Switzerland	53	3.8	52	2.3	63	1.4	51	1.6
Africa	189	9.5	147	5.0	141	6.0	136	6.8
Oceania	176	6.6	164	5.3	187	5.9	191	6.5
Australia	139	5.8	116	4.2	134	5.2	143	5.7

b. Imports

	FY 1986		FY 1987		FY 1988		FY 1989	
	Cases	Value	Cases	Value	Cases	Value	Cases	Value
Asia	15	Y0.3	12	Y0.1	29	Y0.2	26	Y0.3
China	4	*	2	*	0	0.0	3	*
Taiwan	0	0.0	2	*	15	0.0	4	*
South Korea	4	*	4	*	4	*	7	0.1
West Asia	94	10.5	2	*	0	0.0	8	0.1
North America	4,926	174.6	4,747	179.3	5,591	198.1	4,118	210.7
United States	4,825	173.8	4,667	178.6	5,495	196.9	4,029	209.5
South America	4	*	3	*	1	*	1	*
Europe	2,516	85.1	2,568	103.4	2,706	113.6	2,903	118.2
West Germany	903	20.7	847	21.4	835	18.4	1,104	24.3
Great Britain	477	13.0	512	10.3	451	9.3	487	10.8
France	298	7.3	313	22.1	432	26.2	354	25.5
Switzerland	241	17.5	273	17.4	277	18.4	256	19.0
Netherlands	163	15.6	173	20.8	182	27.6	202	21.1
Africa	3	*	3	*	0	0.0	0	0.0
Oceania	28	0.4	38	0.3	29	0.3	53	0.7

*Less than Y50 million.

Source: Management and Coordination Agency, Report on the Survey of Research and Development.

numerical terms in FY 1989 but were up slightly in value terms. Despite these shifts, Japan's technology trade with both the United States and Germany remains deeply in the red.

Perhaps more troubling to developing nations outside of Asia is the lack of attention paid by Japan to this area, according to FY 1989 data. Technology exports to West Asia, South America and Africa have declined over the past four years and show no sign of turning around. Unless this trend reverses, Japan's drive to become a leading source of technology for global development will come up short.

A price analysis of Japan's technology trade reveals some interesting points. The average values of export and import contracts have dogged each other closely over the FY 1975-1989 period. In FY 1975 the average nominal cost of a technology import contract was Y25 million ($185,200) and the cost of an export deal was Y23.7 million ($175,600). The average cost of an import contract rose steadily until FY 1988 when it reached Y37.4 million ($277,000) and then jumped to Y46.4 million ($343,700) in FY 1989. On the export side, the average price followed a similar upward slope, hitting Y43.6 million ($323,000) by FY 1989. Unusual years are evident on both sides of the ledger. In FY 1982 the average import deal jumped from Y36 million ($266,700) to Y40.7 million ($301,500) before dropping back to Y35.6 million ($263,700) the following year. During the FY 1983-FY 1985 period the average value of an export contract rose from Y37.6 million ($278,500) to Y51.1 million ($378,500) then fell to Y39.8 million ($294,800).

Over the entire 15-year period, import contracts averaged Y35 million ($259,300) while export agreements were valued at an average Y37.4 million ($277,000). The results do not change significantly when only new cases of technology transfer are considered; the average new export contract was worth Y36.1 million ($267,400) and the corresponding figure for new imports was Y35.1 million ($260,000). The average price of new technology contracts did show greater year-to-year variability for both exports and imports. (It should be pointed out that Tokyo has no official policy on rates for royalties and license fees. As is the practice in the United States and Europe, decisions by the parties involved in technology transfer negotiations determine prices.) While the greater average value of export contracts speaks well for Japanese business acumen, it raises questions about Tokyo's altruism, which has been suggested by its leaders' espousal of a goal of paying back to the world a perceived technology debt.

New Goals: A Progress Report

The debate in Japan over the nation's new international responsibilities is far from over but its impact on R&D policies already is clear. Government officials have set new goals for Japanese R&D that already are bringing about changes in spending and policies. At present Tokyo has enumerated four new yardsticks by which its R&D policies will be measured: fostering basic research; focusing on environmental issues; transferring technology to developing countries; and internationalizing its R&D system. These four goals often intertwine, sometimes creating positive synergy but also generating problems. Japanese aid officials, for example, are interested in transferring technology to developing nations that not only will make economic sense but environmental sense as well. Conversely, several of Tokyo's proposals for joint international

research (applied and basic) have generated controversy not only overseas but within the Japanese government as well.

Environmental considerations - The previous analysis of government R&D spending by agency already has shown that "green" projects are the latest fad among R&D planners. Substantive projects are being drawn up and implemented as quickly as the budget process allows. The New Energy and Industrial Technology Development Organization (NEDO), a semigovernmental agency affiliated with MITI, added two projects to its Global Environment Technology Program for FY 1991. One seeks to develop methods to manufacture recyclable metal products using alternative energy sources; the other focuses on technology to produce hydrogen from microorganisms instead of fossil fuels. Other projects sponsored by STA and the Environment Agency are aimed at developing alternative energy sources for small-scale use (household-sized solar energy units, for example) and pollution control technologies.

Advocates of nuclear power also have taken up the green banner to support both research on and construction of nuclear power plants. While some environmentalists view this as a perversion of their cause, others point out that Japan must make tough decisions if it is to fulfill a pledge to reduce its output of gases thought to contribute to a greenhouse-like warming of the earth.

Technology transfer - Japan feels it has much to offer developing countries in the way of technology. Because Japan, like many developing countries, is resource poor, it has developed a wealth of appropriate technologies. Small-scale manufacturing and energy systems are just two examples. The Foreign Ministry's Japan International Cooperation Agency and MITI's Japan Overseas Cooperation Volunteers Program (which is modeled after the U.S. Peace Corps) are the main conduits for sending Japanese experts overseas (see JEI Report No. 43A, November 9, 1990).

The primary obstacle to a greater flow of technology from Japan to developing countries lies not with the amount or type of know-how available. Rather, the human/administrative side of the equation is lacking. Foremost, Japan's structure for administering foreign aid is understaffed (see JEI Report No. 47A, December 14, 1990). The number of people available to handle aid requests or travel overseas is limited, although growing. Encouraging private companies to bolster their technology transfer activities, particularly to poor developing countries, is a government priority, but progress has been slow.

Basic research - This is another area where reality lags behind Tokyo's rhetoric. Beginning in the mid-1980s, Japanese leaders have trumpeted the nation's new commitment to basic research. As shown by data on aggregate spending, however, it is clear that there has been little change, so far, in the division of Japan's R&D pie among basic, applied and developmental research. At a finer level of analysis, however, changes are taking place. Outlays for basic R&D programs, such as the Human Frontiers Science Project -- which explores basic body and brain functions, are expanding at a healthy pace. Initial budget requests for FY 1992 indicate that more attention will be paid to basic research, particularly by the Ministry of Education via the nation's universities. Even MITI, whose primary focus is industrial technology, is launching a handful of basic science projects, particularly in the materials science area.

From a foreign standpoint there also is a question about the fundamental nature of Japanese basic research. Even when industry claims it is conducting

basic research, it is often planned or structured to yield a tangible benefit. Experiments in the emerging field of high-temperature superconductivity, for example, often yield prototype devices. This conceptualization of basic research also exists within government. MITI, for example, labels its Basic Technologies for Future Industries program as "fundamental science," yet its projects include development of next-generation computer software languages and quantum-level electronic devices. Japanese basic research often is aimed at finding basic uses for products, not at developing an understanding of the fundamental science that lies behind a particular phenomenon. The meaning of "basic" research, thus, is different in Japan than it is in the United States or Europe.

A major constraint keeping Japanese research priorities from shifting heavily in favor of basic research is the lack of a sufficiently powerful domestic constituency for this change. While private industry says it understands the need to promote basic research in Japan and around the globe, managers' focus on the bottom line naturally limits any actions. More voices within the government are supporting basic research, but they still are in the minority. It will take time for advocates of basic research to build a power base in Japan. Until then, Japanese basic research likely will be typified by a few high-visibility projects rather than a widespread effort.

Internationalization of Japanese R&D - Not only does internationalization imply external ties to foreign research resources and a research presence overseas but invitations to foreigners to engage in or become aware of work within Japan as well. Internal efforts include: the promotion of foreign research activities in Japan, wider dissemination of Japanese research and elimination of the distinctions between Japanese and foreign research activities, at least insofar as government calls for bids. Politics, both domestic and international, plays an inordinately large role in this area, causing problems and obstacles more often than not.

- Government efforts - Besides maintaining a host of bilateral cooperation pacts with major trading partners in a wide range of areas (energy and biological research, for example), Japan has launched several multinational projects. After a rocky start due to questions over funding and awarding of grants, Japan's Human Frontiers Science Program is attracting a growing number of applicants from around the world. In other areas, however, multilateral initiatives are not faring as well.

Japan's response to the Human Genome Project holds several lessons. The project, proposed by American scientists in 1985, is focused on mapping the genetic information of 30 individuals over the next 15 years at a cost of about $3 billion. With such a genetic roadmap scientists hope to open new frontiers for medical diagnostics and therapies. Japan's response to date, however, has been tepid at best. STA has budgeted about $7 million for the project, but other agencies have shown little interest. Even though a professor at Osaka University is a vice president in the Human Genome Organization (HUGO), which coordinates the international effort, he has been unable to generate any interest among public or private researchers. The assignment of a specific HUGO liaison role to a Tokyo University professor named to a scientific council that advises the prime minister may improve, but will not guarantee, the chances for increased or united Japanese action.

The U.S. attempt to gain more foreign investors and participants in its Superconducting Super Collider project raises other points for consideration.

The SSC will use an unprecedented number of superconducting magnets to smash together atomic particles in an effort to understand the fundamental nature of matter and energy. The giant accelerator will cost an estimated $8.5 billion ($11 billion by private estimates), and Washington has asked Japan and other allies to contribute in exchange for access to the facility. Not only is there no natural constituency for the SSC in Japan but a coalition has formed against it. Many Japanese scientists see the SSC as wasteful "big science," yielding meager results for a huge investment. Private firms can see no commercial or technical benefits arising from the SSC and therefore are not interested. Politicians and bureaucrats are unhappy with the project because the U.S. approach has been to ask for money without offering significant participation. With these groups arrayed against it, prospects for Japanese participation in the SSC are bleak.

Tokyo's latest international initiative, the Intelligent Manufacturing System, is moving ahead but at a far slower pace than expected. First proposed in late 1989 by the Ministry of International Trade and Industry, IMS is a universal computer standard that would replace standards that have been developed independently to handle various stages of production. MITI originally was willing to put up two-thirds of the 10-year project's estimated Y150 billion ($1.1 billion) price tag and actively sought participation by private Japanese, American and European firms. Washington and Brussels, worried that the plan was nothing more than a ruse to erase the American and the European leads in some software and engineering areas and to establish Japanese dominance in manufacturing technologies, insisted that the project be handled at the government-to-government level. After several rounds of talks, the three sides have yet to move beyond basic subjects. It does appear, however, that IMS eventually will go forward in a form far different from what Tokyo originally envisioned.

Tokyo's campaign to open existing or planned government-industry research consortia to foreign firms continues to make slow progress. To encourage foreign participation Tokyo has liberalized the rules for joint research projects, paying particular attention to an equitable sharing of resultant intellectual property rights. During FY 1990 and FY 1991 at least seven foreign firms (often via their Japanese subsidiaries) joined or will join new public-private research projects, a cooperative approach credited by some as key to Japan's rapid development of technology. International Business Machines Corp., American Telephone & Telegraph Co. and Siemens AG of Germany will join MITI's program to develop new information processing technology, the so-called Sixth Generation computer project. SRI International of California will participate in two government projects, one to develop the next generation of computer languages and the other involving advanced chemical processing technology. Dow Corning Corp. will participate in a study of silicon-based polymers from FY 1991 through FY 2001. MITI reports that about 10 percent of the companies interested in its upcoming micro-machines project are foreign affiliates.

- Private efforts - As mentioned above, private Japanese firms are under increasing pressure to internationalize their R&D. They have responded in several ways. Japanese companies gradually are opening their research facilities at home to foreigners. Hitachi, Ltd. (35 positions), NEC Corp. (26 openings) and Nippon Telegraph and Telephone Corp. (50 fellowships) include foreign scientists on the staff of some of their top research laboratories. NEC, in particular, has taken the symbolically important step of naming a foreigner to head one of its research labs. Foreign critics point out, however, that such

programs remain tiny in comparison to Japanese access to foreign research facilities.

The importance of tapping Japan's R&D resources is becoming clear to an increasing number of foreign firms. Besides participating in government research projects, foreign companies are examining whether opening their own laboratories in Japan is worthwhile. According to a study done for the National Science Foundation, more than 70 American firms have wholly owned or joint venture research facilities in Japan.[1] The NSF study, based on a 1990 survey of about half these firms, destroys some myths about foreign research in Japan and indicates that it is rapidly evolving.

The study showed that less than 30 percent of the foreign research facilities surveyed were established within the past five years; the majority have been in Japan for more than 10 years. Companies such as IBM, Xerox Corp., Eastman Kodak Co., Mobil Oil Corp. and Dow Corning Corp. have had a research presence in Japan for more than 25 years. Many of the newcomers are in the computer and electronics fields, including Intel Corp., Applied Materials Inc., Apple Computer Inc. and Oracle Corp.; their goal is to seek closer ties to Japanese customers. Like their Japanese counterparts, American R&D subsidiaries were established in Japan to improve the bottom line. Nearly all the facilities were engaged in product development; more than half were engaged in both applied research and process development; less than a quarter performed some basic research. (Only one was engaged entirely in basic research.)

Most interesting were the goals that U.S. firms listed for establishing a Japanese R&D facility. Chief of the "most important" reasons was "to develop products tailored to the Japanese market." This was followed by "the need to meet Japanese government standards." Third among the main reasons was "the desire to gain entry into the Japanese R&D establishment." As for the "least important" reasons, the one most often cited was "qualifying for Japanese government R&D loans or programs." This was followed by "establishing a Far East research base" and "exploiting skills of Japanese scientists and engineers." There was a sharp division on the goal of "increasing effectiveness of absorbing technology developed in Japan," with about 30 percent calling this "very important" but nearly 60 percent saying it was "least important." When foreign firms did try to access Japan's R&D resources, the response was overwhelmingly positive; more than 90 percent said their Japan-based R&D subsidiary gave them better access to Japanese industrial research. The subsidiaries, they noted, also were allowed to join local research associations. Such responses lend weight to Japanese arguments that the technology flow imbalance is due to a lack of foreign interest in Japanese technology and not a lack of access.

Overall, respondents were very satisfied, saying that the Japanese R&D subsidiary had met its objectives. The surveyed firms felt the cost-effectiveness of industrial research in Japan was superior to that in the United States, in part because of the dedication to R&D of both Japanese researchers and managers. Although the costs of establishing a research operation in Japan can be high (many foreign firms report great difficulty hiring all types of employees), investment does pay off. Tokyo has announced several steps aimed at

[1]National Science Foundation, Survey of Direct U.S. Private Capital Investment in Research and Development Facilities in Japan, NSF 91-312 (Washington, DC, 1991).

reducing the cost barrier, including low-interest loans from the Japan Development Bank and some breaks on real estate and local taxes (see JEI Report No. 35A, September 20, 1991). The fact that Japan is at the cutting edge of technology in many areas will continue to attract foreign firms to Japan, possibly improving the flow of Japanese technology overseas.

Conclusion

Japan's well-nourished, healthy and vigorous R&D will ensure that Japanese industry will remain internationally competitive well into the next century. Government and business leaders understand, however, that the global economic and political environment is undergoing some fundamental changes, which entail shifts in Japanese policies as well. As part of its bid to play a larger international role, Tokyo has pledged that Japan will become a net contributor to the world's storehouse of basic and applied knowledge. The small steps in this direction reflected by government and private research budgets show that the shift will take much time, but that movement is occurring.

Equally important to the fulfillment of Tokyo's pledge is the attitude of foreigners to Japanese R&D. Tokyo's multinational R&D initiatives have been met with skepticism and suspicion (often with some justification). Similarly, Tokyo's response to some multilateral initiatives from overseas also has been lackluster. Because private companies play a predominant role in Japanese R&D, the best opportunity for increasing the flow of Japanese technology abroad may be an expanded private foreign research presence in Japan. Rather than bemoaning the competitive threat posed by Japanese R&D, foreign firms might fare better if they tried to turn it to their advantage by becoming insiders in Japan's R&D community.

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The views expressed in this report are those of the author and do not necessarily represent those of the Japan Economic Institute.

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